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(56) Documents cited
GB 2158326 A US 4860281 A US 4686668 A
US 3637954 A

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INT CL[5] H04B 7/00 7/24 7/26 17/00 17/02, H04Q 7/04
W.P.I.

(54) Remote basestation diagnostic subsystem loopback facility

(57) Radio system infrastructure equipment is provided which comprises base station transceiver equipment for communication with a mobile transceiver (20) and diagnostic transceiver equipment (35) associated with the base station transceiver equipment for generating test signals and feeding them to the base station transceiver equipment. A loopback facility is provided within the infrastructure equipment for looping back a signal received from the diagnostic transceiver equipment at a point within the infrastructure equipment. This signal is returned to the diagnostic transceiver equipment, where it is tested, for example by comparison with the original signal, and faults are diagnosed.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 255 881 A

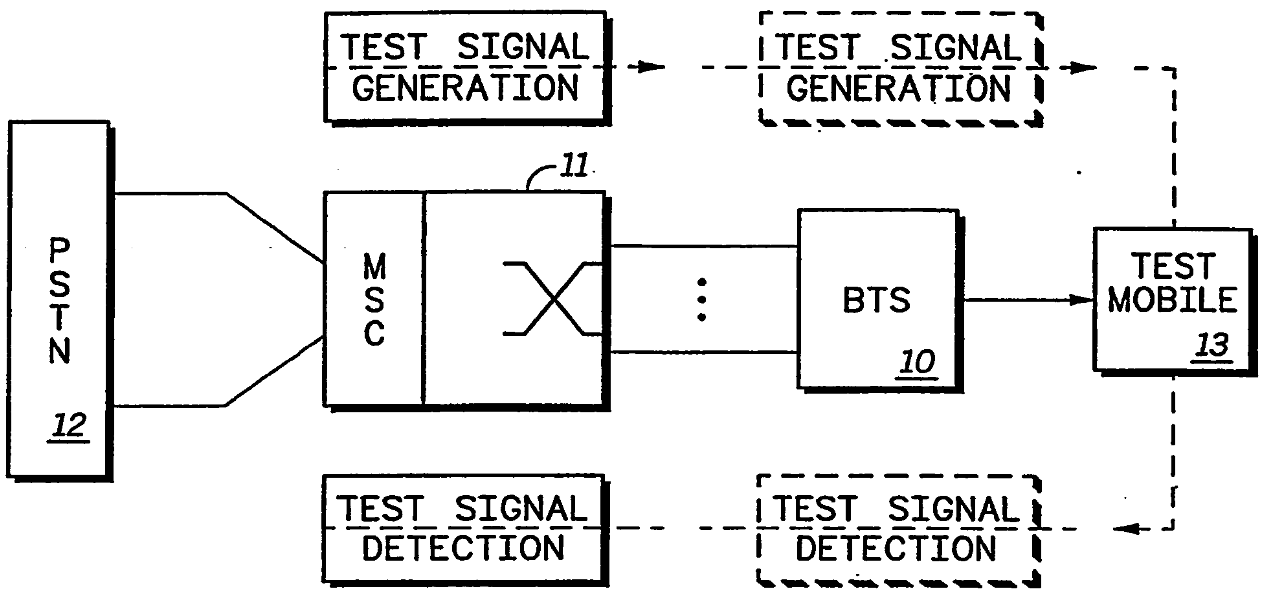
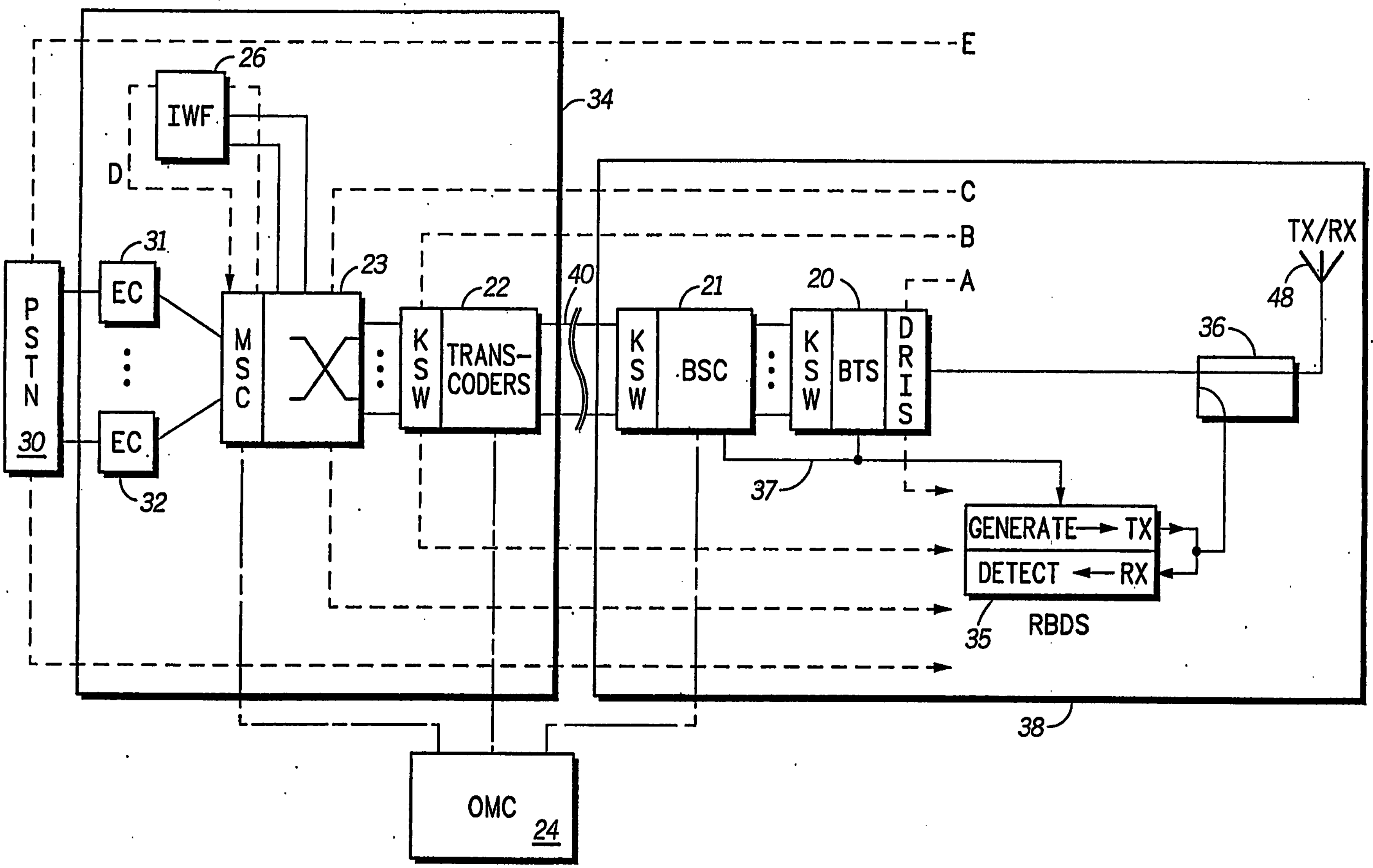


FIG.1
-PRIOR ART-



E
26
IWF
34
D
C
B
31
EC
23
22
40
21
20
A
TX/RX
48
P S T N
30
M S C
K S W
TRANS-CODERS
K S W
BSC
K S W
BTS
D R I S
36
EC
32
37
GENERATE TX
DETECT RX
35
RBDS
38
OMC
24

FIG.2

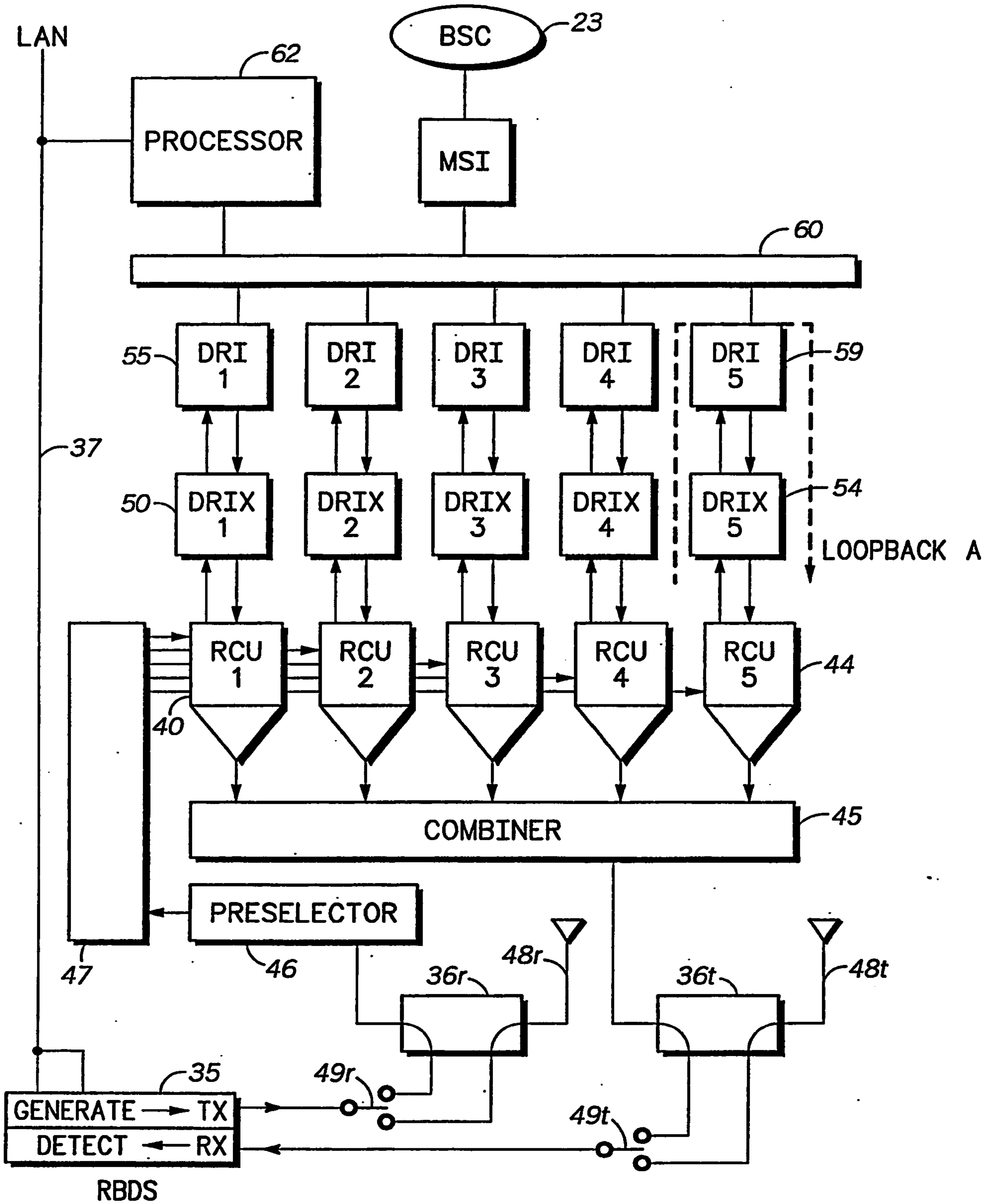

LAN
62
PROCESSOR
BSC
23
MSI
60
37
55
DRI 1
DRI 2
DRI 3
DRI 4
DRI 5
59
50
DRIX 1
DRIX 2
DRIX 3
DRIX 4
DRIX 5
54
LOOPBACK A
RCU 1
RCU 2
RCU 3
RCU 4
RCU 5
44
40
COMBINER
45
PRESELECTOR
47
46
48r
36r
36t
48t
35
49r
GENERATE
TX
DETECT
RX
49t
RBDS

FIG.3

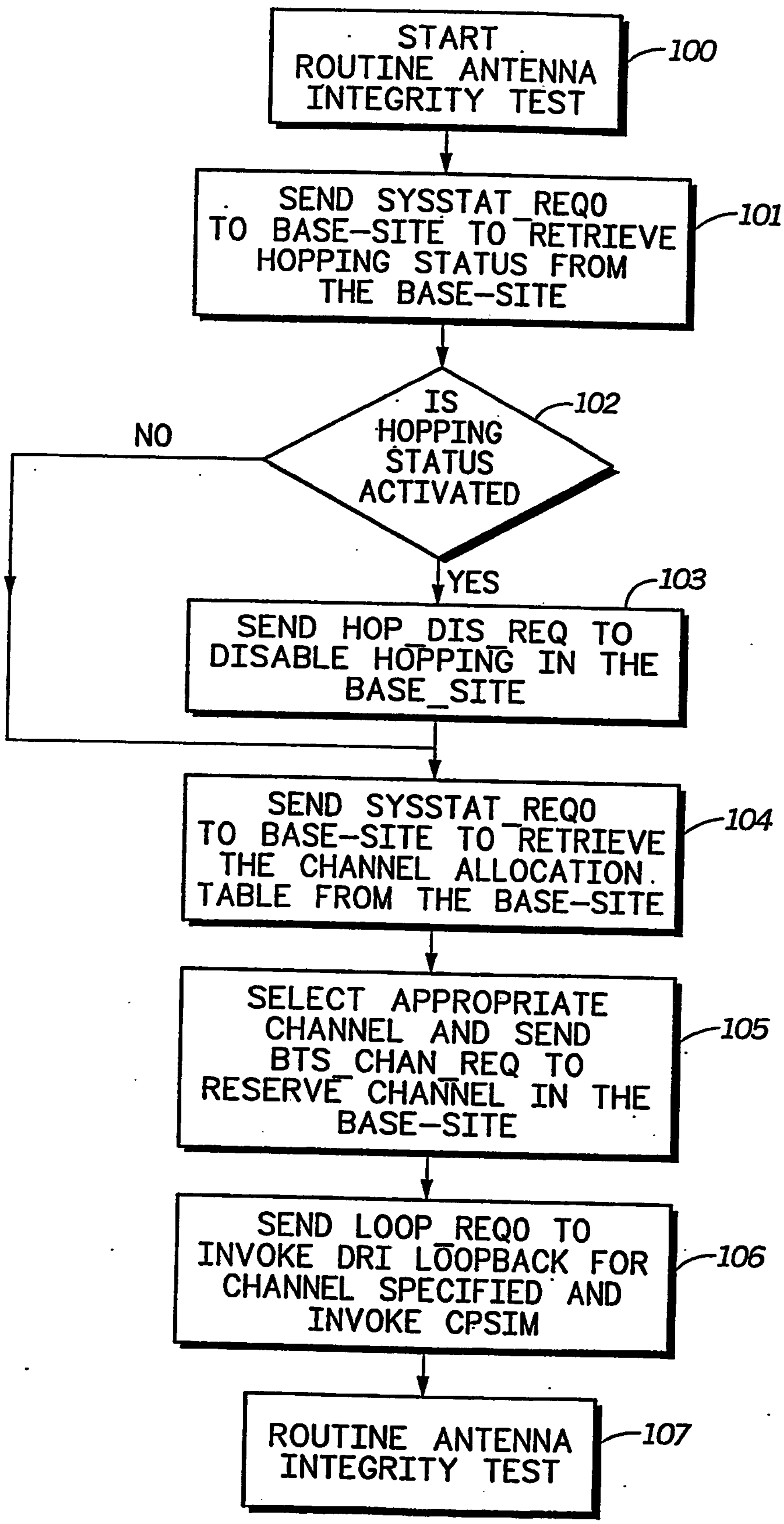

START ROUTINE ANTENNA INTEGRITY TEST
100
SEND SYSSTAT_REQ0 TO BASE-SITE TO RETRIEVE HOPPING STATUS FROM THE BASE-SITE
101
IS HOPPING STATUS ACTIVATED
102
NO
YES
SEND HOP_DIS_REQ TO DISABLE HOPPING IN THE BASE_SITE
103
SEND SYSSTAT_REQ0 TO BASE-SITE TO RETRIEVE THE CHANNEL ALLOCATION TABLE FROM THE BASE-SITE
104
SELECT APPROPRIATE CHANNEL AND SEND BTS_CHAN_REQ TO RESERVE CHANNEL IN THE BASE-SITE
105
SEND LOOP_REQ0 TO INVOKE DRI LOOPBACK FOR CHANNEL SPECIFIED AND INVOKE CPSIM
106
ROUTINE ANTENNA INTEGRITY TEST
107

FIG.4

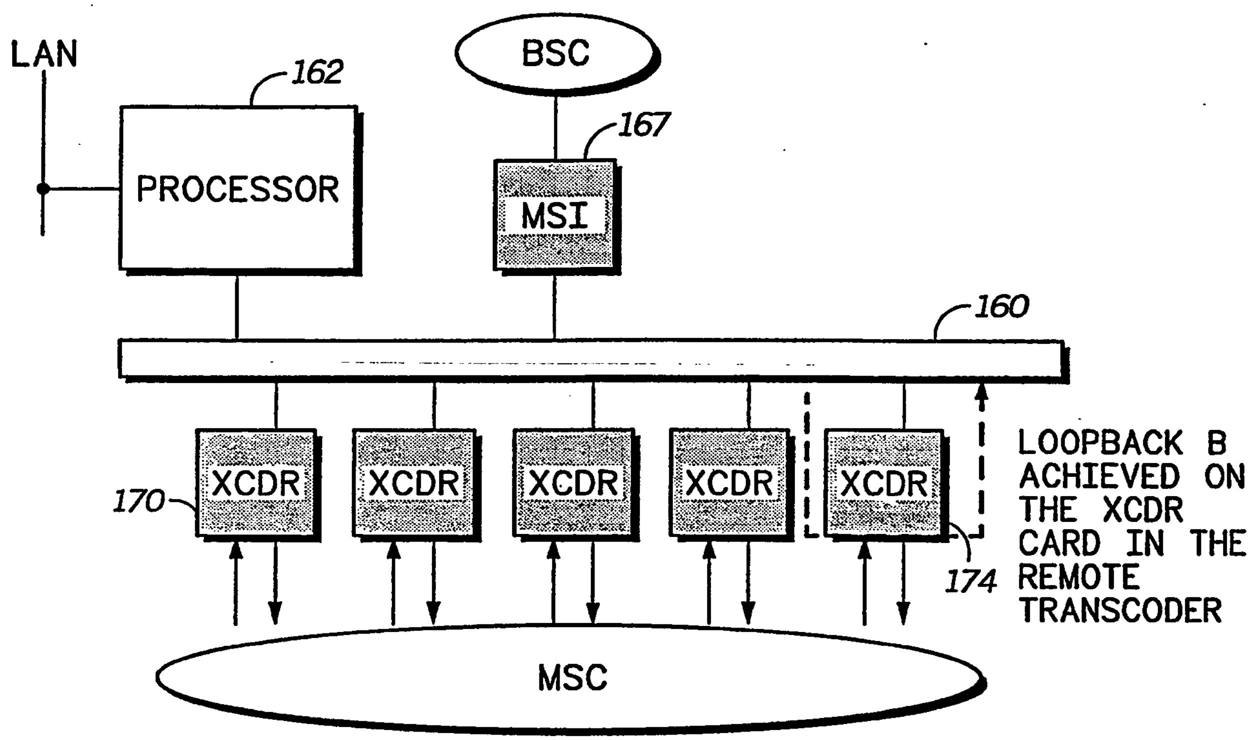

LAN
162
PROCESSOR
BSC
167
MSI
160
XCDR
XCDR
XCDR
XCDR
XCDR
170
174
LOOPBACK B ACHIEVED ON THE XCDR CARD IN THE REMOTE TRANSCODER
MSC

FIG.5

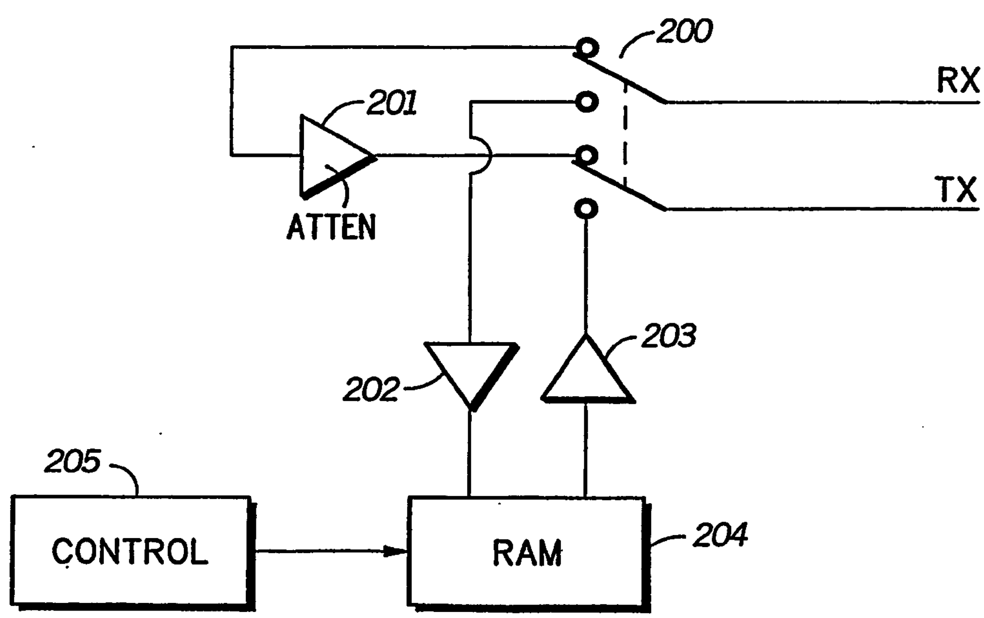

200
RX
201
TX
ATTEN
203
202
205
CONTROL
RAM
204

FIG.6

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REMOTE BASESTATION DIAGNOSTIC SUBSYSTEM LOOPBACK FACILITY

Background of the Invention

This invention relates to radio base stations, such as cellular radio base stations and has particular application in the Groupe Speciale Mobile (GSM) Pan-European Digital cellular radio system. The invention is applicable to other cellular systems such as PCN.

Summary of the Prior Art

In the Total Access Communication System (TACS), i.e. the UK analog cellular radio system, it is known to provide a loop-back facility for setting up test calls. The arrangement is illustrated in Figure 1, in which there is shown a base transceiver station (BTS) 10 connected to a mobile switching centre (MSC) 11, in turn connected to a public services telephone network (PSTN) 12. The base transceiver station 10 is in communication with a test mobile 13, which is able to roam in the field. For the purposes of a loop-back test, the test mobile 13 is stationary at the base site. The operation of a loop-back test is as follows. A test signal is generated at the MSC 11, transmitted to the BTS and in turn transmitted over the r.f. interface to the test mobile 13. At the test mobile 13 the signal is looped back from the receive channel to the corresponding transmit channel, transmitted to the BTS 10 and passed to the MSC 11, where it is compared with the original signal. In this way, the connections from the MSC to the mobile 13 can be tested. The signal looped back at the test mobile is an audio signal.

In the above arrangement, any system entity may set up a call to the test mobile, send audio traffic to it and then monitor the returned traffic. The arrangement is, however, limited in its application and functionality.

UK Patent Application No. 9007330.5 of Motorola Ltd. describes a remote base station diagnostic subsystem (RBDS) which is co-located with a base transceiver station and is

connected thereto by means of a bi-directional RF coupler. The RBDS has the capability of simulating certain functions of a test mobile.

Summary of the Invention

According to the invention, radio system infrastructure equipment is provided comprising base station transceiver equipment for communication with a mobile transceiver and diagnostic transceiver equipment associated with the base station transceiver equipment for generating test signals and feeding them to the base station transceiver equipment, characterised by means within the infrastructure equipment for looping back a signal received from the diagnostic transceiver equipment at a point within the infrastructure equipment, returning it to the diagnostic transceiver equipment and testing the returned signal so as to diagnose faults within the infrastructure equipment.

The infrastructure equipment preferably comprises multiple parallel resources (e.g. parallel RCUs, parallel transcoders, parallel modems) and the diagnostic transceiver equipment comprises control means coupled to the multiple parallel resources for set-up of a selected communication path through the multiple parallel resources, whereby selected resources can be tested under control of the diagnostic transceiver equipment.

The infrastructure equipment preferably comprises multiple serial elements (e.g. one or more of a base tansceiver station, a base station controller, one or more transcoder cards, a MTU, an IWF and a PSTN) and the diagnostic transceiver equipment comprises control means coupled to the multiple serial elements, possibly via an operation maintenance centre (OMC), for selection of an element at which the point of loop-back of the signal is to take place.

The equipment may comprise first and second serial elements (e.g. a BSC and a switch site), the first serial element being coupled to the diagnostic transceiver equipment and the second serial element being coupled to the diagnostic transceiver equipment through the first serial element, the first and second serial elements having control means for communication of control signals therebetween during normal, non-diagnostic operation, the first serial element further comprising simulation means for simulating control signals to the second serial element when a signal received from the diagnostic transceiver equipment is being looped back in the first serial element, thereby to simulate normal operation to the second serial element. This feature has the advantage of minimising disruption of the second serial element while a diagnostic loop-back is being carried out at the first serial element.

The invention, at least in its preferred embodiment, allows a loop-back facility to be controlled by one central device (the RBDS) which can use the results of the tests to locate faults in the system. It should be noted that the direction of the loop-back is reversed vis-a-vis the prior art system. The arrangement allows faults in the system to be localised by the test loops.

In a further aspect of the invention, a maintenance terminal unit is provided which comprises connection means for connection to a public service telephone network (PSTN), comprising storage, delay and replay means for receiving a signal from the PSTN, storing it and automatically retransmitting it to the PSTN after a predetermined delay period. This unit allows a loop-back to be set up all the way through the system from end-to-end, without the looped back signal being cancelled by echo cancellers which may be provided between the radio infrastructure system and the PSTN.

Brief Description of the Drawings

Figure 1 shows a prior art cellular radio system.

Figure 2 shows a cellular radio system in accordance with the invention.

Figure 3 shows detail of a base station controller indicating the implementation of one embodiment of the invention.

Figure 4 shows a flow-chart of an example of a test routine.

Figure 5 shows detail of a transcoder card of Figure 2 indicating the implementation of a second embodiment of the invention.

Figure 6 shows a maintenance terminal unit in accordance with an embodiment of the invention.

Glossary of Terms

By way of explanation, the following explanation of abbreviated terms is given.

BSC	Base Station Controller. This is the controller that has immediate control over a BTS. One BSC may control several BTS's.
BTS	Base Transceiver Station. This is the cellular base transceiver which communicates with the mobiles in a cell.
CPsim	Call Processing Simulator - see below
DRI	Digital Radio Interface
DRIX	Digital Radio Interface Extender Card. This is the communications circuitry for the DRI.

EC	Echo Canceller. This is an echo canceller of known design which cancels echos arising from the PSTN connection.
GSM	Groupe Speciale Mobile.
IWF	Inter-Working Function. The IWF translates modem modulated data from the PSTN to packet data according to the GSM format and vice-versa.
KSW	Kiloport Switch
LAN	Local Area Network
MSC	Mobile Switching Centre. This is an element of every cellular radio system, which controls handoff and other aspect of overall traffic management.
MSI	Mega-Stream (trademark) Interface. This is the link from the MSC to the base site.
MTU	Maintenance Termination Unit - see below.
OMC	Operation Maintenance Centre. This is a processing centre which communicates with all base stations and switches in the system for central reporting of activity and faults.
PCN	Personal Communications Network
PSTN	Public Service Telephone Network.
RAI	Routine Antenna Integrity - see below.
RBDS	Remote Base-Station Diagnostic Subsystem.

RCU Radio Channel Unit. This is a multi-channel transceiver in the BTS.

RXCDR Remote Transcoder card. This is a speech CODEC co-located with the MSC.

TACS Total Access Communication System. This is an existing analog UK cellular radio system.

XCDR Transcoder card. This is a speech CODEC co-located with the base site.

Detailed Description of the Preferred Embodiment

Referring to Figure 2, an overall block diagram of relevant elements of the GSM system is shown. The system comprises a BTS 20, a BSC 21, a series of transcoder cards 22, a MSC 23 and an OMC 24. Associated with the MSC is an IWF 26. The MSC is connected to the PSTN 30 by means of echo cancellers, of which two are shown (31 and 32). The BTS 20 is connected to an RBDS 35 by means of an r.f. coupler 36. Other parallel antennas may be provided (not shown), each with its own coupler. These antennas serve different sectors of the base site or provide for diversity. The RBDS 35 is as described in UK Patent Application No. 9007330.5, with certain additional functions which are described below. There is a LAN 37, for control and data, connecting the RBDS 35 to the BTS 20.

The BTS 20, BSC 21, RBDS 35 and associated elements are generally (but not essentially) located at a base site 38. The KSW 22, MSC 23, IWF 26 and echo cancellers 31 and 32 are generally (but not essentially) located at a switch site 39. A MSL 40 connects the base site 38 to the switch site 39. The two sites may be co-located.

The general operation of the above elements, with the exception of the RBDS 35, is described in the GSM specification.

In Figure 2, a number of dotted lines are shown which represent loop-back tests labelled A to E according to the preferred embodiment of the invention. In each of these loop-back tests, a signal is generated by the RBDS 35, fed to the BTS 20 via the coupler 36 and looped back, at a selected point in the system, to the RBDS where a test can be made, for example by comparison of the generated signal with the looped back signal. Where a fault is detected, this is reported to the OMC 24.

The loop-back tests A to E are described in greater detail below.

Loop-back A

The first loop-back test to be described is illustrated by dotted arrow A and is set up at the base site 38.

Referring to Figure 3, the BTS 20 is shown in greater detail. It comprises five RCU's 40 to 44, an RF combiner 45, a preselector 46, and a 6-way splitter 47. The combiner 45 is a filter network which directs different transmit signals of different frequencies to different antennas. There are a number of receive antennas (e.g. six) connected to the preselector 46, of which one is shown as antenna 48r, and a number of transmit antennas (e.g. six) connected to the combiner 45, of which one is shown as antenna 48t. Connecting the RBDS 35 to the preselector 46 and the combiner 45 are r.f. couplers 36r and 36t. Associated with each RCU is DRIX 50 to 54 and DRI 55 to 59. The DRI's 55 to 59 are connected to a bus 60. Connected to the bus is a processor 62 and MSI 67. The MSI interfaces with the MSC 23 of Figure 2. The processor 62 interfaces with the LAN 37.

loop-back A illustrated in Figure 2 is achieved in hardware terms by looping the signal from the RBDS received

through the combiner and through one of the RCUs (e.g. RCU 44) through the associated DRIX and mapping it in the DRI 59 from the receive channel to the corresponding transmit channel. The mapped signal is then fed back through the DRIX 54 through the RCU 44 through the combiner 45 to the RBDS 35.

The receive and transmit channels are on different frequencies and different time slots. The DRI 59 stores the digital signal, delays it to the appropriate transmit timeslot and reads it out again from memory during that time slot. The RCU 44 receives the signal from the DRIX and transmits it on the appropriate transmit frequency.

Example - routine antenna integrity (RAI) test.

As an example of a test set up by the RBDS in a loop-back call through the DRI 59 of the BTS 20, the RAI test will be described. A flow diagram of the test is shown in Figure 4. The test illustrates two advantageous features of the loop-back facility: (A) resource selection in the loop-back path and (B) the isolation of resource use to within the loop-back path.

In the cellular system, resources are allocated autonomously by the base site and by the switch in non-trivial manner. To locate faults it is therefore desirable to be able to allocate a test call from the RBDS along a pre-selected path through the system. This is achieved by the RBDS using the technique of resource selection in the loop-back explained below.

Referring to Figure 4, the routine integrity test (step 100) is initiated by the RBDS. In step 101, the command SYSSTAT-REQ0 is sent from the RBDS to the BTS via LAN 37 to retrieve hopping status from the processor 62 of the BTS. In this way, the RBDS requests the status of frequency hopping in the BTS, whether activated or de-activated. If the hopping status is "activated" (step 102), a command HOP-DIS-REQ is sent from the RBDS to the BTS, causing the disabling

of hopping in the base site (step 103). The system is now ready for testing. The RBDS sends a command SYSSTAT-REQ0 to the BTS to retrieve the channel allocation table. The table is read out from the processor 62 to the RBDS over the LAN. By examining this table, the RBDS has the ability to select a particular resource in the base site to test. In particular, the RBDS can select a particular channel and, according to the frequency thereof, it can select different antennas for testing. In step 105, the RBDS selects the channel to be tested and sends the command BTS-CHAN-REQ to reserve that channel in the base site. In this way, a channel is chosen which will test a particular transmit antenna. It will be understood that the same principle applies for any base site resource, both in software and in hardware (e.g.RCUs). In step 106, the RBDS sends the command LOOP-REQ0 to the BTS, which causes the DRI 59 to map the received channel to the transmit channel. At the same time, a software routine referred to as CPsim is implemented as follows.

To establish a call to test the loop-back would normally involve signalling between the base-site 38 and the switch site 39. It would be preferable to avoid the need for a test operation which is purely local to the base site to have any effect on the switch. To make the test call as non-intrusive as possible and to avoid the overhead of unnecessary signalling on the long-distance connection between the base site 38 and the switch site 39, the BSC makes use of a call processing simulator CPsim. This in effect simulates the signalling that the base site would expect from the switch during a call set-up. The CPsim software emulates the signalling associated with establishing the loop-back test, thereby avoiding involving the switch and the signalling channel on the control interface (the A-Interface) over the MSI 40 between the MSC 39 and the base-site 38.

In this way the loop-back is set up and the routine antenna integrity test (step 107 of Figure 4) can be carried

out. The test may, for example, be a simple voltage standing wave ratio (VSWR) measurement.

The test is carried out by transmitting a normal cellular radio signal modulated with an audio test signal from the RBDS to the RCU 44 via preselector 46 and splitter 47, with two-way switch 49r in its upper position as shown. When the signal is looped back. it is transmitted to antenna 48t. By switching the switch 49t from its upper position to its lower position as shown and comparing the strengths of the signals from the combiner 45 and reflected from the antenna 48t respectively, a VSWR measurement can be made by the RBDS. Alternatively, the RBDS simply measures the reflected power and compares it with the anticipated transmit power as reported over the LAN 37.

The process can be repeated for a different channel corresponding to a different frequency and a different antenna.

Having described an example of a loop-back test at the base site, it will be apparent to one skilled in the art that other tests can be made at the base site. Further loop-back paths will now be described as illustrated in Figure 2.

Loop-back B

This loop-back path is located in the transcoder card 22. The loop-back is set up by means of a command from the RBDS to the OMC 24 and from the OMC to the transcoder card 22. The transcoder card 22 comprises 30 separate transcoders, each having its own digital signal processor. The command from the RBDS causes a particular one of the transcoders to loop-back an audio signal (after transcoding) and return the signal on the opposite channel to the RBDS. The transcoder transcodes the signal from the 13 Kbps rate to the 64 Kbps rate, loops it back and transcodes again to the lower rate. The RBDS may use spectral analysis to analyse the returned signal. The transcoder on each channel may be

tested by setting up calls on each channel in turn. If the transcoder card 22 is remote at the MSC as shown in Figure 2, this must be co-ordinated by the OMC. Alternatively, if the transcoder card is located at the base site 38, the resource may be selected by the RBDS without involving the OMC.

Referring to Figure 5, the hardware implementation of the loop-back is illustrated. The figure shows a transcoder card 22 comprising a bus 160, a processor 162 and a MSI 167, similar to the equivalent units in the base site 38. The processor 162 interfaces with a LAN 137 which extends around the switch site 39. Connected to the bus 160 are five XCDRs 170 to 174, which are connected to the MSC 23. The XCDRs contain digital signal processors and codec software for performing the transcoding function.

In Figure 5, the loop-back is shown as taking place in XCDR 174. Under control from the processor 162, the XCDR 174 decodes the traffic on its receive channel (i.e. received from the BSC 21) from the lower data rate of 13Kbps encoded audio, in accordance with the GSM specification, to the higher rate of 64Kbps digitised audio, stores this, maps it across to its transmit channel (i.e. to be transmitted to the BSC 21) in the appropriate transmit time slot, encodes it to the 13Kbps rate and transmits it to the BSC for return to the RBDS 35.

At the RBDS 35 the returned signal can be compared with the original signal. The signals cannot be compared bit-by-bit, because substantial distortion will have taken place in the transcoding process. The transcoder is designed to maintain the characteristics of a human voice and accordingly, it would require a human ear to determine whether the quality of the voice is preserved. For the purposes of the test, however, other methods are employed. In the preferred embodiment, the audio signal generated by the RBDS is a pure sine wave and spectral analysis is carried out on the returned signal. Particularly, the harmonics of the returned signal are analysed and if these do not fall

within expected limits, a fault is registered and reported to the OMC 24.

Loop-back C

Loop-back C is performed in the MSC 23. It allows the RBDS to set up a call, and pass audio to the MSC which returns the traffic to the RBDS for checking. The OMC is asked by the RBDS to select a particular path through the MSC so that each part of the MSC may be tested and faults isolated.

Loop-back D

Loop-back D is performed in the IWF 26. A data signal is transmitted from the RBDS through the BTS 20 and the BSC 21 to the MSC 23. Because the signal is a data signal, the MSC 23 routes the call to the IWF 26, which translates it to a normal telephone modem signal. Instead of passing the modem signal to the PSTN 30, the IWF loops back the signal, translates it back to GSM data format and passes it back to the BSC 21 and the BTS 20. The RBDS receives the loop-back signal and can compare the transmitted data with the received data.

Loop-back E

A problem arising from attempting to loop-back through the PSTN is the use of the echo cancellers 31 to 32. A signal looped back without delay would be recognised by the echo canceller as a large echo and would be removed. To facilitate a PSTN loop-back in the GSM system, it is proposed, in accordance with a preferred embodiment of one aspect of the invention, to provide a maintenance termination unit (MTU) as follows.

The MTU is a stand-alone unit connected to any PSTN connection, with its own PSTN telephone number. The MTU is illustrated in Figure 6. It comprises switch means 200, a loop-back with a fixed attenuator 201, D/A and A/D convertors 202 and 203, RAM memory 204 and control means 205. In addition, the MTU comprises further standard circuitry which need not be described.

The RBDS initiates a call to the unique telephone number of the MTU in the PSTN. The PSTN routes the call to the MTU and, on receipt of the call, the MTU is activated. The time before answering the incoming call is adjustable. Once the call is answered, the MTU operates in two different modes, as determined by the switching means 200. In the first mode (illustrated by the upward position of the switching means) audio is simply looped back from the receive line to the transmit line, with fixed attenuation through the attenuator 201. In the alternative mode (illustrated by the lower position of the switching means 200), the signal is converted to digital form by the A/D convertor 202 at the PCN standard rate of 64 KBPS and is stored digitally in the RAM 204. Ten seconds of data are recorded, including all line activity (tones, voices, pops, crackles). During this recording process, the MTU detects periods of silence by detection of a number of consecutive samples of less than a predetermined amplitude and then plays back the ten seconds of data through the D/A convertor 203 to the transmit line. It will be understood that, if the signal is periodic, it does not matter whether it it the last ten seconds, the first ten second, or any other portion of the signal that is retransmitted, provided that the signal is stored for a sufficient period of time before re-transmission, such as to exceed the period of operation of the echo cancellers 31 and 32. There may be a further delay between the end of the receive operation and the start of the retransmit operation.

The effect of the MTU is to store, delay and replay the received signal after a period of 10 seconds, which is

outside the range of operation of the echo cancellers 31 and 32. Thus, the replayed audio is not cancelled by the echo cancellers and is received at the RBDS for comparison with the signals sent.

In this manner, a complete path through the GSM system from mobile to PSTN may be tested.

Claims

1. Radio system infrastructure equipment comprising base station transceiver equipment for communication with a mobile transceiver, diagnostic transceiver equipment associated with the base station transceiver equipment for generating test signals and feeding them to the base station transceiver equipment, characterised by means (20, 22, 23, 26, 200) within the infrastructure equipment for looping back a signal received from the diagnostic transceiver equipment (35) at a point within the infrastructure equipment, returning it to the diagnostic transceiver equipment and testing the returned signal so as to diagnose faults within the infrastructure equipment.

2. Equipment according to claim 1, wherein the infrastructure equipment comprises multiple parallel resources (40-44, 55-59, 26, 170-174) and the diagnostic transceiver equipment comprises control means coupled to the multiple parallel resources for set-up of a selected communication path through the multiple parallel resources, whereby selected resources can be tested under control of the diagnostic transceiver equipment.

3. Equipment according to claim 2, wherein the multiple parallel resources comprise radio transceivers (40-44, 55-59).

4. Equipment according to claim 2, wherein the multiple parallel resources comprise parallel transcoders (170-174).

5. Equipment according to claim 2, comprising inter working function equipment (26) having a plurality of modems for translating between a packet data format and a modem data format, and wherein the multiple parallel resources comprise the plurality of modems.

6. Equipment according to any one of the preceding claims, wherein the infrastructure equipment comprises multiple serial elements and the diagnostic transceiver equipment comprises control means coupled to the multiple serial elements for selection of an element at which the point of loop-back of the signal is to take place.

7. Equipment according to any one of the preceding claims, comprising first (38) and second (39) serial elements, the first serial element being coupled to the diagnostic transceiver equipment and the second serial element being coupled to the diagnostic transceiver equipment through the first serial element, the first and second serial elements having control means for communication of control signals therebetween during normal, non-diagnostic operation, the first serial (38) element further comprising simulation means (CPsim) for simulating control signals from the second serial element when a signal received from the diagnostic transceiver equipment is being looped back in the first serial element, thereby to simulate normal operation to the second serial element.

8 Equipment according to any one of the preceding claims, further comprising a connection for a public service telephone network (PSTN) characterised by a maintenance terminal unit having a connection for the PSTN and comprising storage, delay and replay means for receiving a signal from the diagnostic transceiver equipment through the PSTN, storing it and automatically retransmitting it to the diagnostic transceiver equipment after a predetermined delay period.

9. Equipment according to any one of the preceding claims, wherein the means for looping back the signal includes a maintenance terminal unit comprising connection means for

connection to a public service telephone network (PSTN) having an echo canceller (31, 32), the maintenance terminal unit comprising storage, delay and replay means (204, 205) for receiving a signal from the PSTN on a receive line, storing it and automatically retransmitting it to the PSTN on a corresponding transmit line after a predetermined delay period which exceeds the period of operation of the echo canceller.

10. Equipment substantially as hereinbefore described and as shown in Figure 2, 3, 5 or 6.

-18-

atents Act 1977 xaminer's report to the Comptroller under ection 17 (The Search Report)	Application number 9207811.2
elevant Technical fields (i) UK Cl (Edition K) H4K (KFF,KFL,KYR); H4L (LFM) (ii) Int Cl (Edition 5) H04B 7/00, 7/24, 7/26, 17/00, 17/02; H04Q 7/04	Search Examiner N W HALL
Databases (see over) (i) UK Patent Office (ii) W.P.I. ON-LINE	Date of Search 30 JULY 1992

Documents considered relevant following a search in respect of claims 1-10

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2158326 A (STC) See Figure 1	1 at least
Y	US 4860281 (MOTOROLA) See Figure 2B	1 at least
Y	US 4686668 (N.E.C.) See column 6, line 13 - column 7, line 5	1 at least
Y	US 3637954 (BELL) See Figure 1	

SF2(p)

Kim - doc99\fil000206

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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